Section 2

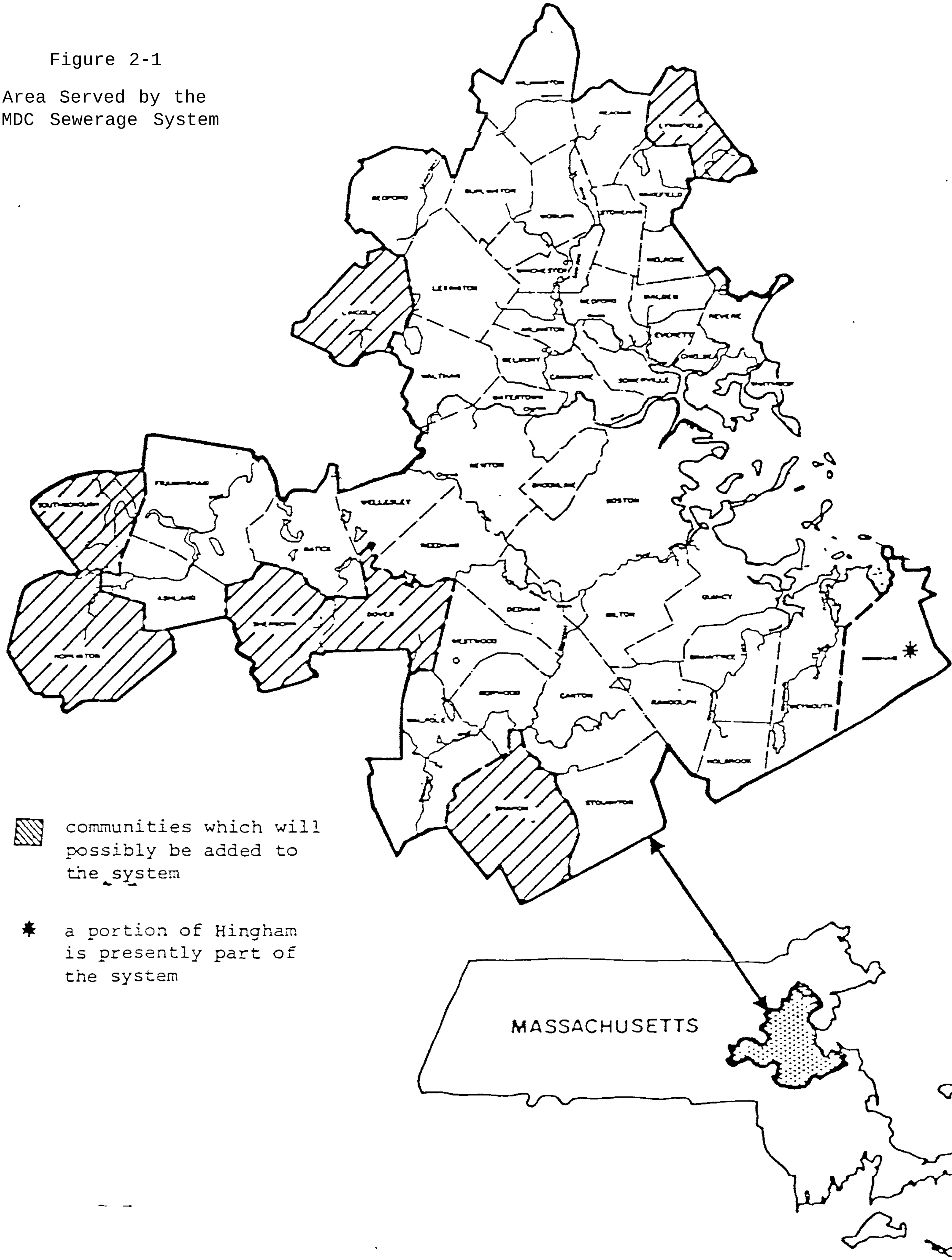
Municipal Sewage Treatment Plant Operations, Options and Water Quality Impacts

The 43 towns and cities belonging to the Metropolitan Sewage System (see Figure 2-1) generated approximately 167,900 million gallons of raw, mixed domestic, commercial, and industrial wastewater in 1980. Among the responsibilities of, the Metropolitan District Commission (MDC), a public service authority for the 43 municipalities, is the collection, treatment and disposal of these municipal wastes. To fulfill its responsibility, the MDC owns and operates two sewage treatment plants (STP), one at Deer Island and the other at Nut Island, which handle the wastes from the northern and southern member municipalities, respectively. At present, both plants are designed to carry out primary treatment, which is essentially a screening, sedimentation, and chlorination procedure. They then discharge both the treated effluent and concentrated, digested sludges into the outer harbor.

Under the legal mandate of the 1972 and 1977 Clean Water Act and Amendments, the Environmental Protection Agency (EPA) established standards and procedures for the treatment and disposal of municipal wastes. The new regulations call for treatment at the secondary level (in addition to primary treatment) and a cessation of sludge disposal in the ocean. The intent of the regulation is to reduce the degradation of water quality that is caused by municipal waste loadings.

Figure 2-1

Area Served by the
MDC Sewerage System



communities which will possibly be added to the system

✱ a portion of Hingham is presently part of the system

Prompted by the aforementioned regulation, numerous studies have been undertaken to determine the engineering feasibility of treatment alternatives, how to manage and handle residual sludges, etc. For the most part, these studies have limited their analyses to what can be done to satisfy the new regulatory requirements, either through direct compliance (secondary treatment and no sludge discharges to the ocean) or with options available through waiver opportunities (upgraded primary treatment with a deep ocean outfall, sludge barging).

Section 3 discusses the technical, environmental, and financial options for combined sewers in the Boston Metropolitan area. STPs are discussed here separately. At times it will be necessary to bring combined sewers into the following discussion since their performance can affect that of the STPs and vice-versa.

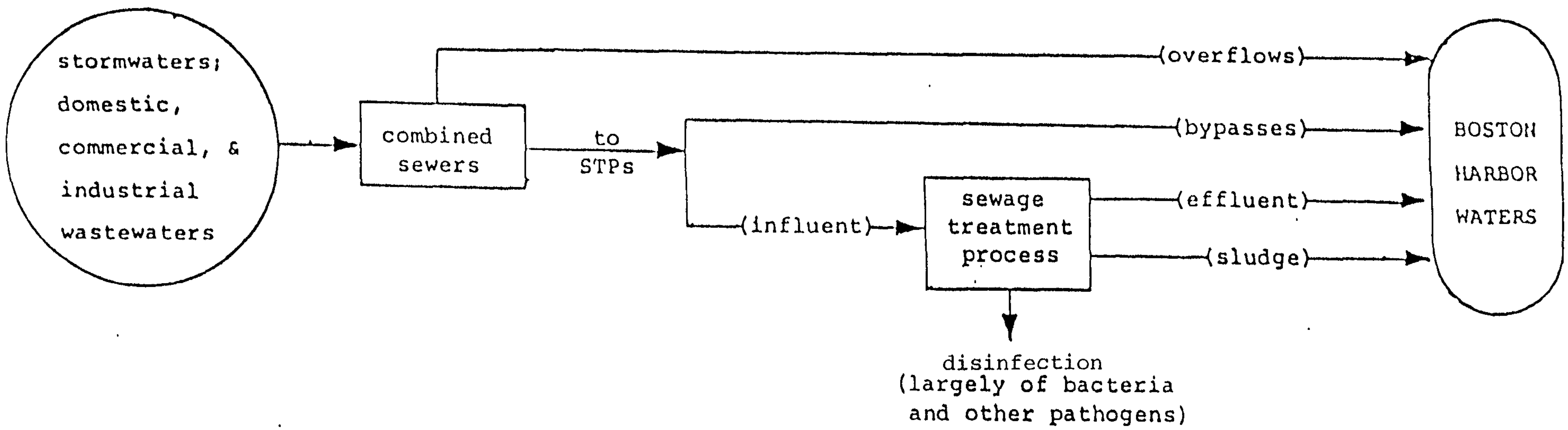
The intent of this section is to: (1) describe current Deer and Nut Island STP performance and pollutant loadings; (2) present the financial and expected performance characteristics of two proposed STP options; and (3) discuss the potential water quality impacts of these proposed STP options. A vast amount of information was analyzed for the development of this chapter. What is presented here is essentially the conclusions of that effort. The background and formulation of the most important analyses are explained in Appendix A.l.

2.1 Current STP Performance

The existing Deer Island and Nut Island STPs are designed to treat municipal wastewaters at the primary level. As the flow diagram of Figure 2-2 illustrates, most constituents of the municipalities' wastewaters eventually

Figure 2-2.

Schematic of Sources of Pollutant Loadings to Boston Harbor



reach the harbor in one form or another, with the exception of a portion of the organic constituents which are lost through disinfection in the treatment process. Metals and other non-destructables remain relatively unchanged while passing through the treatment system and are, therefore, discharged in either the sludges or effluent from the STPs.[a/] The STP-source loadings have been calculated on an annual basis for comparison of their relative magnitudes: they are presented in Table 2-1. Effluent and sludge loading information was calculated using measurements taken of wastewaters that had undergone complete treatment, which does not account for raw (untreated) wastewater discharges. Therefore, loadings from STP bypasses of raw wastewaters were calculated from influent composition and bypass volume data.[b/]

Both the treated wastewaters and the solids sludges extracted by STP treatment are discharged through local outfalls into Presidents and close to Nantasket Roads from the Deer Island and Nut Island STPs, respectively. These two "Roads" are the major deep and fast-flowing channels of the Harbor (see Figure 2-3 for their location). Whereas much of the harbor is only 10 to 15 feet deep, the depths of President and Nantasket Roads range up to 90 feet. The STPs discharge to these locations because of their capacity for carrying and dispersing effluent and sludge loads. The plants' effluents are discharged continuously whereas sludges ideally are released only on outgoing tides. Since the sludges generally contain a high percentage of the original influent's pollutants, their releases are timed for maximum removal from the

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a/ Some chemical recombination and physical change of the wastewater constituents can be expected, but essentially, mass is conserved.

b/ CSO loadings have not been calculated from this same raw wastewater information because data regarding the frequency, duration, stormwater dilution, and volumes of overflow events are not available.

Table 2-1.

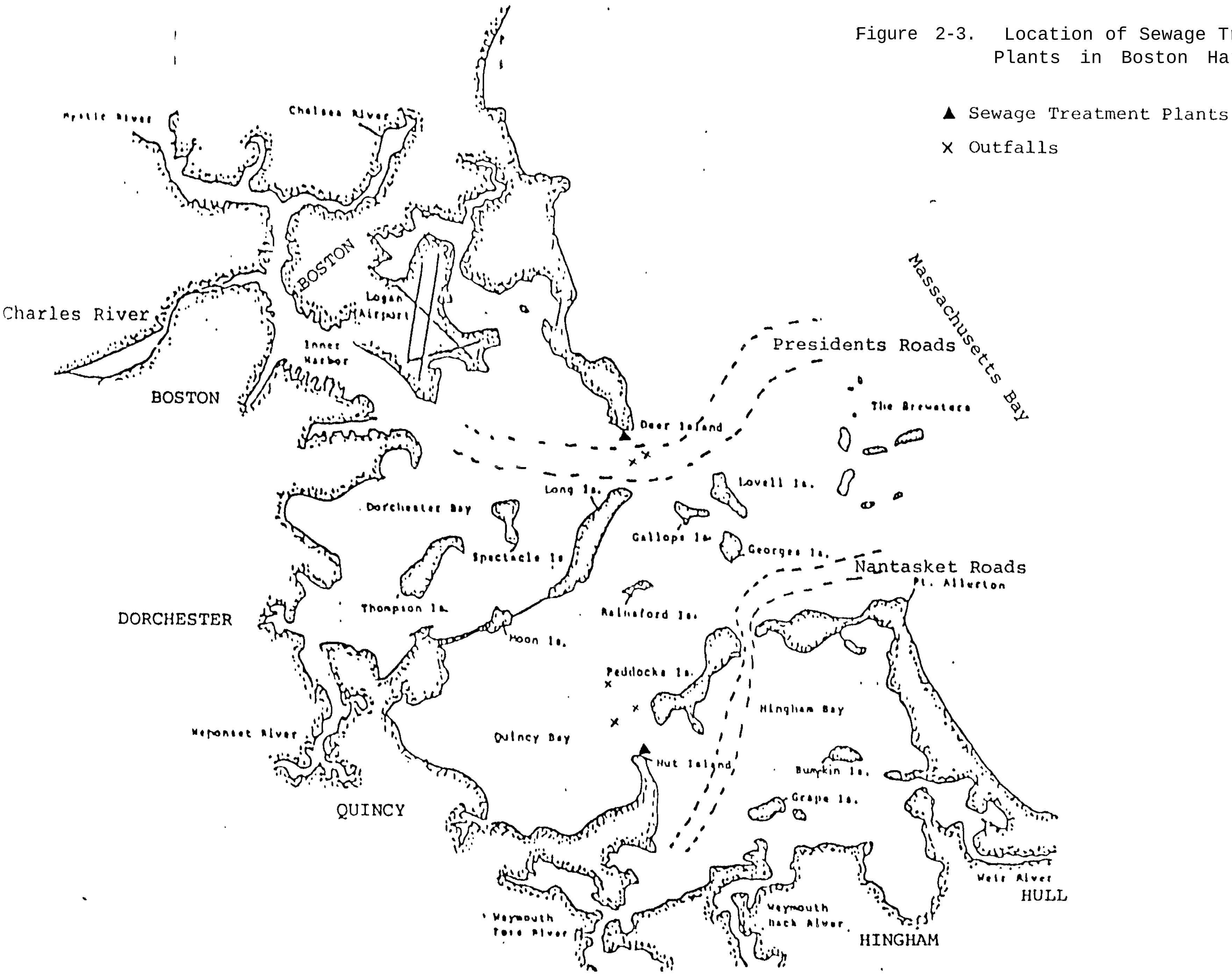
Comparison of STP Loadings
for Deer and Nut Islands Combined a/

	Existing Loadings				STP Effluent from Ocean Outfall (lbs/yr)	STP Effluent from Secondary Treatment (lbs/yr)
	STP Effluent (lbs/yr)	STP Sludges (lbs/yr)	STP Bypasses (lbs/yr)	Total STP Discharges (lbs/yr)		
BOD_5	154×10^6	17×10^6	$10\text{-}15 \times 10^6$	$181\text{-}186 \times 10^6$	180×10^6	46×10^6
TSS	124×10^6	45×10^6	$10\text{-}15 \times 10^6$	$179\text{-}184 \times 10^6$	135×10^6	46×10^6
Cd	26,000	4,800	1,000	31,800	26,000	23,000
Cr	138,000	72,600	4,700	215,300	138,000	101,000
Cu	325,000	115,700	22,400	463,100	325,000	159,000
Pb	178,000	36,500	6,300	220,800	178,000	141,000
Hg	2,000	700	100	2,800	2,000	1,500
Ni	241,000	25,900	22,700	289,600	241,000	172,000
Zn	702,000	222,700	29,000	953,700	702,000	419,000

a/ Conversions of mg/1 data to 1bs/year figures made assuming 500 million gal/day of effluent discharged from Deer Island and Nut Island combined. See Appendix A.1 for further explanation of calculations.

Sources: US EPA (1978), Tables 3.2-6 and 3.2-7; US EPA (1983), p.2; Metcalf & Eddy (1982), Tables 3-10 and 3-11; ERT (1978), Table 2.2-8; Dimanoski (1982).

Figure 2-3. Location of Sewage Treatment Plants in Boston Harbor Study Area



Harbor. However, due to outfall pipe deterioration, inadequate holding capacity, and system malfunctions, the sludge releases are not always properly co-ordinated with the tides. Hydroscience's model of sludge transport from the outfalls predicts that 20 percent of the sludges discharged on the outgoing tide are carried back into the Harbor on the return tide.

The Deer and Nut Island STPs are currently operating below design criteria. This has led to:

a. the bypassing of raw sewage directly into the Harbor;

b. the release of sludges on currents other than the outgoing tide;

c. the backing up of sewers from the STP, causing the combined sewers to overflow; backups can occur if some unit of the STP malfunctions, halting incoming flows or if incoming flows simply exceed the capacity of the system;

d. overall, less than design-optimal treatment performance because of tanks settling, tank covers missing, screens in poor condition, pumps malfunctioning, and other operational problems, including the problem of saltwater influent into STP due to malfunctioning tide gates.

A properly operating and properly sized sewage treatment system could alleviate these problems. Necessary steps to correct the above deficiencies include:

a. improving the capacity of the combined sewers (particularly holding facilities) in order to moderate heavy (storm) flows to the STPs; repairing STPs to restore capacity (pumping, etc.); expanding STPs to increase capacity (of holding tanks, etc.);

b. that sludges be released only on out-going tides (sludge-release timing problems) or that another method of sludge disposal be found;

c. that either or both of the following actions be taken to solve the influent back-up problem:

  - expand combined sewer facilities to accommodate what the STP cannot, and/or
  - increase STP ability to accept incoming flows;

d. the repair of units to restore their design functions and performance.

Funds recently have become available for the repair and rehabilitation of Nut and Deer Islands' STPs, which may restore their original design performance. Increased operation and maintenance efforts made by the MDC can result in a change in the Harbor's water quality prior to implementation of any of the proposed STP options. Actual loadings to the Harbor might be *more* consistent with the sum of the first two columns of Table 2-1 once the STPs are operating well, whereas now the loads are higher since bypassing occurs.

2.2 STP Options and Costs

There are many options under consideration for STP modification. They represent different combinations of primary and secondary level treatment facilities at Deer, Nut and/or Long Islands, with either local or deep ocean outfalls. Two options have been chosen for the purposes of this analysis: (1) upgraded primary treatment with a deep ocean outfall and (2) secondary treatment with a Presidents Roads (local) outfall. Because of resource limitations, only two options could be included.

At the time of this analysis several other options are under discussion[a], but all are either primary treatment with a deep ocean outfall or some type of secondary treatment. Thus, the options described here are meant to be representative of the range of options possible under current federal regulations.

One of the STP options considered here calls for upgrading the existing facilities to achieve primary treatment plus the construction of a deep ocean outfall diffuser system to discharge the combined, treated effluents from Deer and Nut Island plants into the waters of Massachusetts Hay, out of the Inner Harbor estuary, at a depth of 32 M (105 feet) (see Figure 2-3). The outfall system would consist of a 10 foot diameter pipeline extending 4.7 miles from Nut Island; 56.6 cubic meters per second (1.29 billion gallons per day) capacity effluent pumping station on Deer Island; and an outfall tunnel 7.5 miles long and 19 feet in diameter, terminating at a diffuser manifold 1.3 miles in length. The proposed deep ocean outfall would discharge the treated effluents from the Deer Island and Nut Island facilities. At the mouth of the outfall would be a diffuser, which is designed to rest on the ocean floor at a depth of approximately 100 feet.

The other STP option includes expanded primary treatment at the Nut Island facility with the waste flow sent to Deer Island where all of the system's wastes would be treated at the secondary level. The combined local outfall would be into President's Roads (see Figure 2-3).

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[a] See CE Maguire (1983). Specific options were chosen in consultation with Region I, Environmental Protection Agency, personnel. At the time of this analysis these were the options preferred by the MDC.

The capital and operating and maintenance costs for the two STP options are presented in Table 2-2, and the expected loadings in terms of pollutant concentrations are compared to concentrations in the existing STP effluents in Table 2-3. These options and their associated costs assume that the present facilities operated by the MDC will be modified according to the presently planned "fast-track improvements". The costs of these immediate upgrade improvements will be $10 million at Nut Island and $40 million at Deer Island (CE Maguire, 1983).

2.3 Areas Impacted by STP Discharges

Existing water quality in different areas in the Harbor is due to current STP effluent discharges, bypasses and sludge discharges as well as the natural composition of the waters, CSOs, surface runoff, long-term discharges to the harbor (industrial, residential STPs, etc.), discharges from marine craft, etc.

In terms of the incremental contributions to pollutant concentrations made by STPs, some areas are impacted more than others. The affected areas may be grouped as follows (see Figure 2-4):

- areas of heaviest loadings;
  - between Deer Island and Long Island
  - between Long Island and Love11 Island
  - Quincy Bay, south of Moon Island
  - between Nut and Peddocks Island

- areas of moderate loadings:
  - east of Love11 Island
  - western half of Hingham Bay
  - northwest and northeast of Deer Island STP
  - Quincy Bay shoreline

Table 2-2. Costs of the Two STP Options

(Millions 1982$)

Wastewater Treatment STP Options	Capital Cost (1983$)	Capital Cost (1982$)[a/]	Annualized Costs Capital[b/]	Annualized Costs O&M	Annualized Costs Total
Upgraded Primary With Ocean Outfall	774.8	728.9	74.9	22.0	96.9
Secondary	887.4	834.8	85.8	45.2	131.0

a/ Expressed in 1983 (ENR=3825) because benefit estimates are expressed in 1982$ (CPI-U=289.4)

b/ Based on 8 1/8 percent interest and 20 year period.

Source: CE Maguire (Draft, 1983), Table 2. These costs are to be considered preliminary estimates only.

Table 2-3. Pollutant Concentrations in Effluent for STP Options

Effluent Pollutants		Misting STP	Ocean Outfall Option	Secondary Option
BOD_5	mg/1	107	115	30
	% removal	29	28	81
TSS	mg/1	87	86	30
	% removal	55	47	81
Cadmium	mg/1	.017	.017	.015
	% removal	15	15	25
Chromium	mg/1	.090	.090	.066
	% removal	16	16	38
Copper	mg/1	.212	.212	.104
	% removal	39	39	70
Lead	mg/1	.116	.116	.094
	% removal	19	19	34
Mercury	mg/1	.0011	.0011	.001
	% removal	21	21	28
Nickel	mg/1	.157	.157	.112
	% removal	72	72	80
Zinc	mg/1	.458	.458	.273
	% removal	33	33	60

Sources: US EPA (1978), Tables 3.2-6 and 3.2-7; US EPA (1983), p.2; Metcalf & Eddy (1982), Tables 3-10 and 3-11.

Note: Existing values for the metals are averages of sampling done in years 1975-1977. Samples taken in 1982 show decreases in chromium, lead, and zinc with increases in the other metals (Metcalf & Eddy, 1983). Whether this represents a significant decreasing trend can only be ascertained through a concerted monitoring plan.

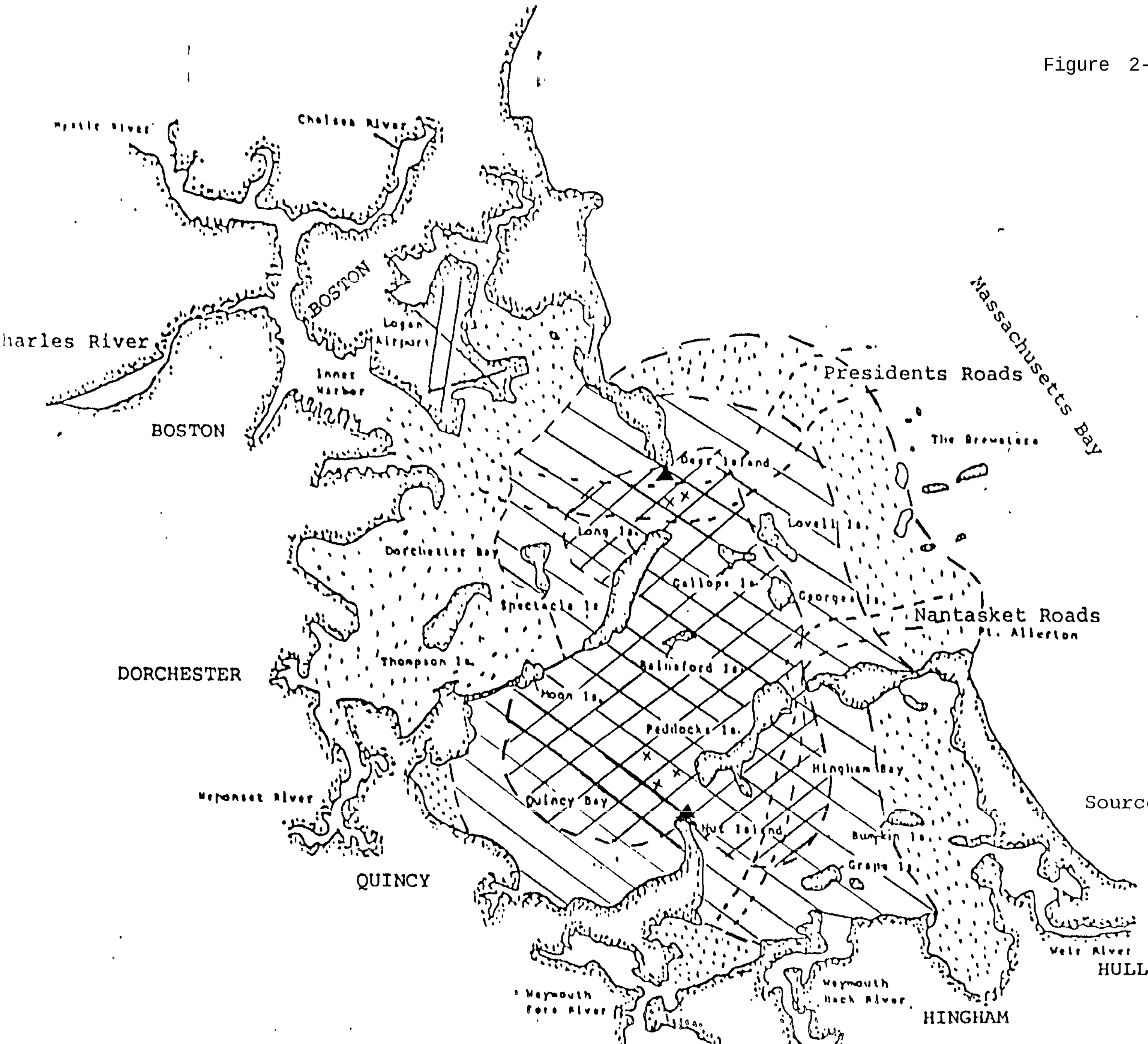


Figure 2-4. Dispersion of Current STP Discharges

Source: Metcalf & Eddy (1979), Figure 6-16.

- o areas minimally influenced by STP discharges:
  - the Brewsters Islands
  - eastern half of Hingham Bay
  - Inner harbor
  - Dorchester Bay shoreline
  - Neponset River

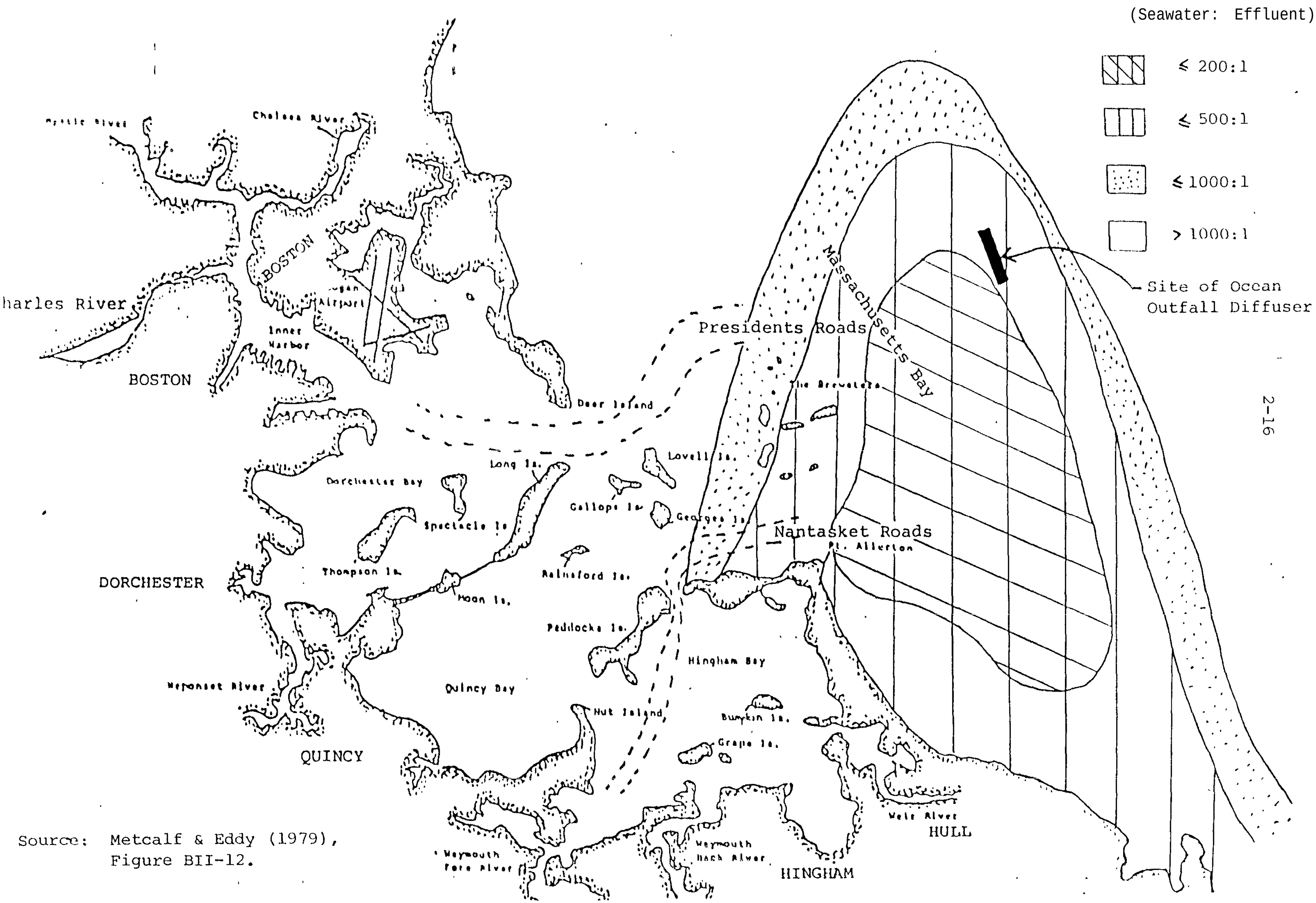
The highest pollution loads are located along the incoming and outgoing tidal paths of Presidents and Nantasket Roads (the two main current channels of the harbor, in which Deer Island and Nut Island STPs have their outfalls, respectively). Current STP discharges have a greater impact on the Outer Harbor Islands and the eastern part of Quincy Bay than on the other shoreline at the perimeter of the harbor.

If a deep ocean outfall option is selected, the harbor will certainly experience a reduction in pollutant loadings. The reduction for the harbor creates a trade-off, however, by introducing wastes to previously unpolluted areas. Figure 2-5 identifies three zones of impact for the proposed ocean outfall option. In terms of the areas of concern to this benefits study, the zones which sustain degradation of water quality due to the construction of the deep ocean outfall are:

- o Massachusetts Bay (highest level of impact); and
- o Nantasket Beach and the Brewsters (moderate level of impact).

The advantage of the proposed deep ocean outfall is the dilution of effluent that is obtainable in its vicinity as compared to the dilution in the vicinity of the local outfalls currently in use in the harbor. The disadvantage is that total pollutant loadings are not reduced to the extent they would be under the secondary treatment option, and the proposed location may not provide for sufficient transport and dispersion of the diluted wastewater.

Figure 2-5. Dispersion of Proposed Ocean Outfall Discharges

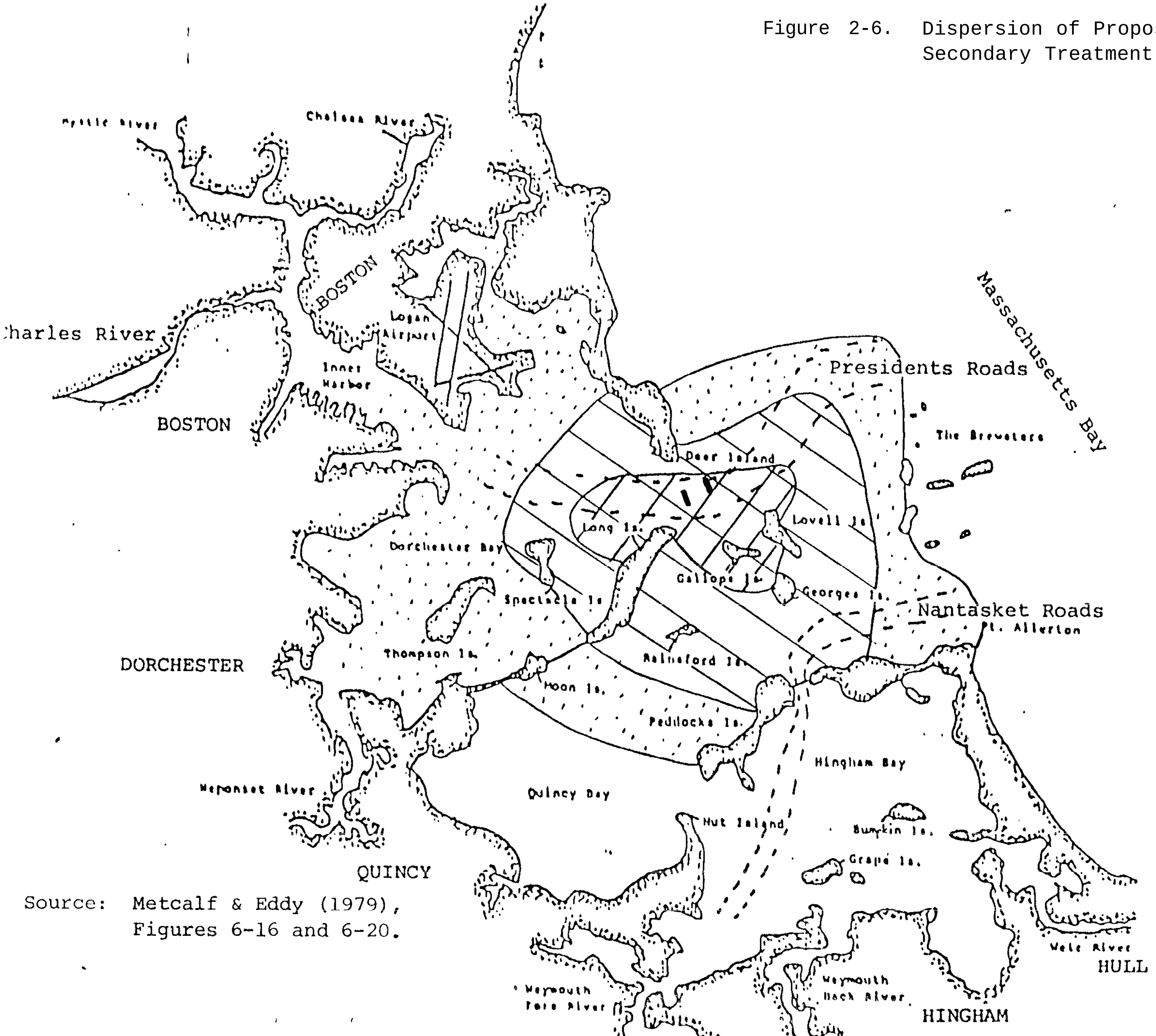


Source: Metcalf & Eddy (1979), Figure BII-12.

The secondary treatment option considered in this study will reduce total pollutant loadings and change the location of the current STP discharges in Nantasket and Presidents Roads to a single discharge within the harbor in Presidents Roads. Figure 2-6 identifies the areas in the harbor which will be affected by this discharge. The highest level of impact will be on the Outer Harbor Islands.

None of the proposed STP options will eliminate the pollution of harbor waters. The incremental loadings to the harbor waters can be reduced, thereby improving water quality. Most pollutants (i.e., metals and solids) tend to settle out of the water column and into the sediments. Therefore, the pollutant concentrations of Boston Harbor sediments will probably continue to rise unless the rate of pollutant loading can be supressed by some sort of biological, chemical, or physical neutralization process within the sediments. What happens to pollutants in sediments is not known, however, nor are the effects on aquatic organisms of pollutant build-up in sediments fully understood. The present and potential status of water and sediment qualities can be quantified but the significance of such qualities is not clear.

Figure 2-6. Dispersion of Proposed Secondary Treatment Discharges



Dilution Ratio

(Seawater:Effluent)

≤ 50:1

≤ 100:1

≤ 200:1

> 200 to 1000:1

Diffusers

Source: Metcalf & Eddy (1979), Figures 6-16 and 6-20.

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Section 3

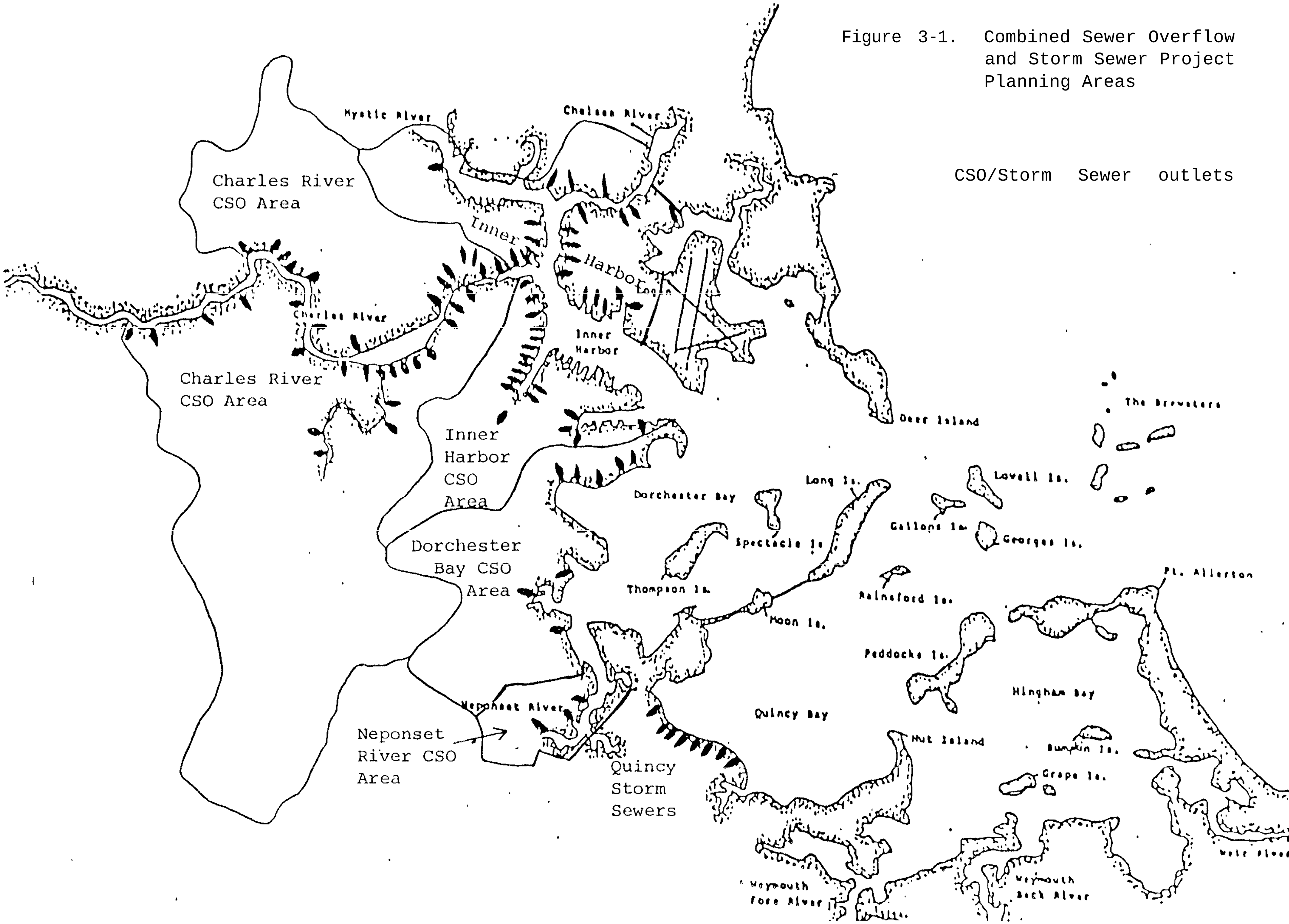
Combined Sewer Overflow Control in Boston Harbor

In its effort to develop a comprehensive plan for combined sewer overflow (CSO) control in Boston Harbor, the Metropolitan District Commission (MDC) has designated four CSO planning areas. The four areas are defined on the basis of their existing water use and coastal use patterns. The designated areas are: (1) Dorchester Ray, (2) Neponset River, (3) Inner Harbor and (4) Charles River Basin (see Figure 3-1). In addition, the City of Quincy has storm sewer outfalls into Quincy Bay which may impact the study area in a manner similar to the CSOs. For each of these five planning areas engineering firms have been hired to study alternative methods of control. All information pertaining to specific areas is drawn from the contractor reports, and these reports are referenced at the end of this Section.

3.1 Scope of the Combined Sewer Overflow Problem

The water quality of all four planning areas is compromised by pollution from combined sewer overflows, stormwater discharges, and dry weather overflows (DWO) (see Figure 3-1). Storm-related combined sewer overflows vary in duration (depending on the nature of the storm) and occur from 50 to 100 times a year (depending on the planning area location). Dry weather overflows may be caused by sewer blockages, regulator malfunctions and/or tide gate failures. DWO's are continual discharges of sanitary

Figure 3-1. Combined Sewer Overflow and Storm Sewer Project Planning Areas



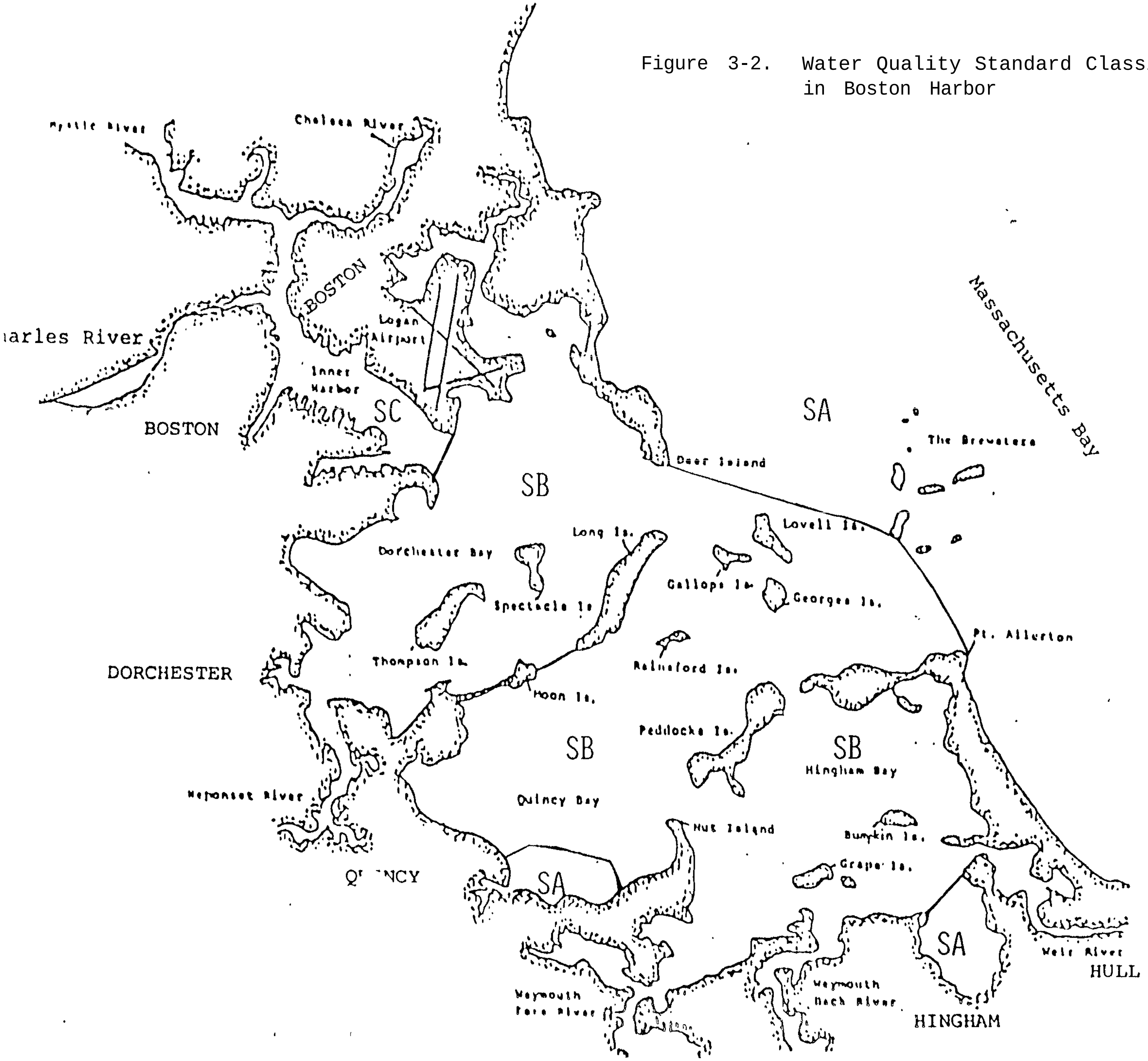
wastewater and are considered by the MDC to be the single most important source of pollution in Boston Harbor. Treatment of dry weather overflows is considered in all the CSO plans.

Different parts of Boston Harbor have different standards (see Figure 3-2). The Dorchester Bay and Neponset River Estuary areas are both classified as SB. An SB classification implies suitability for primary water contact sports (i.e., swimming) and shellfishing and means that the dissolved oxygen in the water must be greater than 6.0 mg/1 and the total coliform count must have a median level less than 700 MPN/100 ml The Inner Harbor is classified as SC which makes it suitable for secondary recreation and means that dissolved oxygen must be greater than 6.0 mg/1 and the total coliform count must have a median not greater than 1000 MPN/100 ml The Charles River is classified as "C", the fresh water counterpart of SC, which makes the river suitable for secondary recreation.

Some areas of Quincy Bay and Hingham Bay, outside the CSO planning areas but within this studies' boundaries, are classified SA. An SA classification is the same as SB for DO but has stricter limits on total coliform counts (70 MPN/10 0ml) for the protection and propagation of aquatic life and so that shellfish harvesting can take place without depuration in approved areas (Metcalf & Eddy, 1979). The plan for the city of Quincy's storm sewers is discussed separately below (Section 3.6).

The MDC and its contractors found the following violations of the standards, of which all of the violations are caused jointly by combined sewer and dry weather overflows (MDC, April 1982) and by STP loadings:

Figure 3-2. Water Quality Standard Classifications in Boston Harbor



- Coliform bacteria standards are intermittently or continually violated in all areas.
- Dissolved oxygen standards are frequently violated in the Charles River Basin planning area and in the Inner Harbor; they are less frequently violated in Dorchester Bay and the Neponset River Estuary and Constitution Beach.
- Suspended solids possibly limit the most sensitive designated uses of receiving waters; settleable solids cause violations in certain locations, and floating materials, oil and grease violate the standards in all areas. The standards for all of these parameters are non-quantitative.
- Nutrients are creating enriched conditions conducive to excessive algal growth in fresh waters in the Neponset River Estuary.
- Heavy metals are potentially significant contaminants to finfish and shellfish in all areas.
- The shellfishing standards for total coliforms are violated in the Neponset River Estuary, in much of Dorchester Bay, and in areas north and east of Logan International Airport.

In order to deal with these violations, the MDC concluded that its efforts to upgrade water quality should meet the following objectives (MDC, April 1982):

a. eliminate dry weather overflows;

b. reduce the frequency and volume of untreated CSO's

c. reduce the release of pathogenic organisms and floating materials;

d. and reduce the release of settleable organic solids and other oxygen demanding material, nutrients and toxics.

Control Plans designed to meet these objectives were developed for each of the planning areas by the MDC's contractors. Table 3-1 lists the costs and water quality characteristics of the planning areas. The Recommended Plans, and the types of benefits to the area in which they will be implemented, are explained in more detail in the remainder of this Section.

3.2 Neponset River Estuary

The Neponset River Estuary Planning Area contributes to pollution in both the river estuary and Dorchester Harbor. The area is approximately 60 percent residential and five percent industrial with remaining acreage being either open space or commercial/institutional property. Tenean Reach, in Dorchester Harbor, and the shellfish beds in the estuary both experience what the MDC terms "extremely high levels for both total and fecal coliforms, The contractor's survey of the planning area determined that combined sewer and dry weather overflows accounted for over 90 percent of the annual total coliforms. Combined sewer overflow also was a major contributor to floating and suspended solids. The contractor's survey of the in-place sewerage facilities revealed broken or malfunctioning tide gates, malfunctioning regulators, and much solid deposition in the conduits. The fact that downstream interceptors had reduced flow due to sedimentation also compromised this planning area's ability to discharge its waste through normal channels.

Table 3-1.

CSO Planning Area Characteristics

Planning Area	Annualized Capital Costs a/ (MM 1982$)	Annual O & M Costs (MM 1982$)	Total Annualized Costs (MM 1982$)	Receptors	Water Quality Classification	Fecal Col. per 100ml	Total Col. per 100ml	Sus. Solids mg/l	Turb. NTU	BOD_5 mg/l	Total Phos. mg/l	DO mg/l
Inner Harbor c/ Constitution Only	14.63 0.04	1.97 0.01	16.61 0.05	<u>Shellfish:</u> Airport <u>Beaches:</u> Constitution	SC T.col $\leq$ 1000 DO $\geq$ 6.0	36- 1.5×10^6	230- 4.6×10^6	0-27	1.0-3.1	0.7-92	0.08- 0.86	1.3- 12.2
Dorchester Bay c/	4.97	0.37	5.34	<u>Shellfish:</u> Dorchester Bay <u>Beaches:</u> Castle Is. Pleasure B. Carson Malibu Tenean	SB T.col $\leq$ 700 DO $\geq$ 6.0	36- 9,300	36- 46,000	3.0- 14.0	0.1	.8-79	0.3-0.6	3.6
Neponset River b/	0.61	0.10	0.71	<u>Shellfish:</u> Neponset Estuary <u>Beaches:</u> Tenean	SB T.col $\leq$ 700 DO $\geq$ 6.0	geom mean 6,800	geom mean 38,000	45	1.5	3.2	.22	5.2
Charles River d/	8.87	1.56	10.43	No shellfishing or swimming	C T.col $\leq$ 1000 DO $\geq$ 6.0		300- 12,000	0.09- 34.0	0.2- 5.0	0.4- 9.6	0.01- 0.61	0.0- 12.6
Quincy e/	0.25	-0.02	0.27	<u>Shellfish:</u> Quincy Bay <u>Beaches:</u> Wollaston Quincy	SA T.col $\leq$ 70 DO $\geq$ 6.0	500- 18,000	800- 34,000	5- 50		1- 5.0		6- 10

a/ Based on 8 1/8 percent interest and a 20 year payback period.

b/ Values for Neponset River are from data gathered in August 1978 (DEQE, 1982).

c/ Values for Dorchester Bay and Inner Harbor are from the CSO Facilities Plans (Camp Dresser & McKee, 1981; O'Brien & O'Gere, 1980).

d/ Values for the Charles River are from data gathered by the MDC (Ferullo, 1981).

e/ Values for Quincy are from sampling conducted in June-August 1982.

The Recommended Plan for this area focused initially on dry weather flow abatement, and in this vein the Plan starts with recommendations to fix or replace faulty tide gates, clean and inspect conduits, and re-open the blocked regulators that in their present condition contribute to DWO. Some new conduit and storm drain construction is recommended, both of which are intended to reduce CSOs. The planning area is divided into two subsections, each of which is slated to receive a storage and chlorination facility. Such facilities will store combined sewage until such time that the downstream treatment system can handle it.

According to the contractor's report, this Plan will reduce total coliforms loadings by 96 to 99 percent. The costs are summarized in Table 3-2. Such a reduction will have several benefits, the most calculable being fewer days during which total coliforms exceed the water quality standards for swimming at Tenean Beach. In 1970, the Massachusetts Department of Public Health issued a report on Dorchester Bay beaches indicating that the fecal coliform counts at Tenean Beach were above the guideline of 200 MPN/100 ml for bathing water in 35 to 54 percent of the grab samples and total coliforms exceeded the 1000 MPN/100 ml guideline in 24 to 43 percent of the samples. As a result of the findings regarding these coliform counts and the fact that sewage was clearly being discharged into Tenean Beach, the Department of Public Health recommended in its 1970 report that the beach be closed for 24 hours after a rainfall of 0.25 inches or more in a 24 hour period. The Recommended CSO Plan will alleviate much of the reported pollution, reduce the need for closing Tenean Beach and, thus, contribute significant recreational (especially swimming) benefits.

Table 3-2. Combined Sewer Overflow Project Costs
(1979$)

Neponset River Estuary

Improvement	Capital Costs[a]	O&M Costs[b]
I. Granite Avenue Service Area		
1. Rockwell St. Drain	47,000	120
2. Stockton St. Drain	48,000	120
3. Washington St. Drain	66,000	170
4. Hilltop St. Drain	29,000	77
5. Ballet St. Drain	73,000	180
6. Adams St. Sewer	72,000	180
7. Granite Ave. Truck Sewer	696,000	1,740
8. Davenport Brook and Granite Ave. (Regulator upgrading)	30,000	880
9. Catch Basin Cleaning		25,000
10. Monitoring Program	3,000	12,000
11. Granite Ave. Storage Facility	1,341,000	4,100
12. Net Cost at Deer Island		2,290
II. Port Norfolk Service Area		
1. Chickatawbut St. Pump Station	150,000	4,000
2. Lawley St. Relief Sewer	207,000	520
3. Regulator Rehabilitation	8,000	
4. System Inspection and Cleaning	10,000	5,000
5. Port Norfolk Storage Facility	1,752,000	15,000
6. Net Cost at Deer Island		960
Total Costs		
Total Cost for Granite Avenue Service Area	2,405,000	46,850
Total Cost for Port Norfolk Service Area	2,127,000	25,480
Total Cost for Entire Plan	4,532,000	72,330

a/Based on June 1979 price levels (ENR 2900) and includes an allowance for engineering and contingencies.

b/Based on 1979 price levels.

Source: Havens and Emerson, 1980.

The benefits of reducing these coliform counts in the Neponset River Estuary are less clear because the Recommended Plan affects only the mouth of the river. Total coliform loadings upstream of the planning areas are considerable and are unaffected by the Recommended Plan. There are 40 acres of soft shell clam beds in the estuary, most of which are currently classified as grossly contaminated. At present there is not sufficient evidence to predict, with certainty, whether or not the Recommended Plan for the Neponset River Estuary Planning Area will allow those shellfish beds to be opened.

A final benefit of the Recommended Plan has to do with the aesthetic upgrading of the area due to the reduction of odor and floatable solids. In addition to quality of life benefits, such an upgrading may also result in an increase of secondary recreational water use (such as boating and the development of boat ramps and yacht clubs).

3.3 Dorchester Bay

Dorchester Bay is used mainly for swimming, boating and shellfishing. Of all the planning areas it has the highest density of beaches. There are five beaches in the Bay, seven yacht clubs, and 75 acres of shellfish (soft shell clam) beds. Most of the shellfish beds are currently closed to harvesting and four of the beaches are known to exceed total coliform standards after rain storms in the summer.

This degradation of Dorchester Bay's water quality is in large part caused by eleven combined sewer outlets that discharge into waters adjacent to public beaches. Unlike the Neponset River Estuary Planning Area, the Dorchester Bay Planning Area has a wastewater collection system that is in good condition. The contractors discovered "no major structural deficiencies in the regulators, tide gates or sewer manholes.

Several maintenance-related problems were discovered, generally consisting of blockages within the sewers and regulators due to excessive sediment buildup. These maintenance problems and a small number of direct dry weather connections to overflow conduits that were also discovered, result in several dry weather flow dischargers to Dorchester Bay* (Camp, Dresser and McKee, 1981).

The Recommended Plan for the Dorchester Bay Planning Area includes a DWO abatement program and an ongoing program to maintain high operating efficiency in the tide gates and regulators, It also calls for a one and one-half mile consolidation conduit designed to intercept CSOs at the outlet tide gates and to transport the waste to a storage facility. A final part of the plan involves the construction of the two screening and disinfection facilities to protect the Dorchester Beaches during the bathing season. Table 3-3 presents the costs for the Recommended Plan.

According to the contractor's calculations, DWO abatement in the Dorchester Bay Planning Area will result in the attainment of the required water quality standards over the long run. Short-run storm-induced episodes of elevated coliform counts can be avoided by the addition of CSO controls. For all but the most extended heavy storms, the Recommended Plan will reduce total coliform loadings by 98 percent.

In addition the Recommended Plan will greatly reduce the level of floatable solids, oil and grease in Dorchester Bay. Such changes will be particularly beneficial to a planning area that is used primarily for recreation and shellfishing. Reduced coliforms and a reduction in floatable solids will have the direct benefit of increasing swimming and improving

Table 3-3.

Combined Sewer Overflow Project Costs

(1979$)

Dorchester Bay

I. Structural	Capital[a/]	O & M[b/]
South Boston		
- Consolidation Conduit	9,620,000	
- Storage/Containment Facility	18,380,000	38,000
Dorchester		
- Hoyt St. Regulator Modification	90,000	
- Commercial Point Screening/ Disinfection Facility	3,030,000	22,000
- Fox Point Screening/ Disinfection Facility	2,740,000	21,000
- Pine Neck Creek/ Storm Drain Relocation	2,340,000	
Subtotal	36,200,000	81,000
II. Non-Structural		
Dry weather flow abatement program	100,000	
Post Management Practices	25,000	200,000
Subtotal	125,000	200,000
III. Additional		
Cleaning of CSO Conduits	300,000	
Dredging	40,000	
Landfill at CSO Outlet BOS-090	20,000	
Subtotal	360,000	-0-
Total	36,685,000	281,000

[a/] Based on June 1979 price levels (ENR 2900) and includes an allowance for engineering and contigencies.

[b/] Based on 1979 price levels.

Source: Camp, Dresser and McKee, 1981.

health through decreasing the number of pathogens in the water. Shellfishing should, over time, increase as bed acreage is opened to harvest.

3.4 Inner Harbor

The Inner Harbor Planning Area has two distinct uses. The majority of the planning area is classified for commercial use while a very small section, Constitution Beach, is classified for swimming. To deal with these divergent uses Table 3-4 is divided to show the costs of attending to the Inner Harbor proper and Constitution Beach separately. The Inner Harbor proper is characterized by industrial, transportation, shipping and energy production uses. The area to the north and east of Logan International Airport has shellfishing and recreational uses similar to the Dorchester Bay. There is swimming at Constitution Beach and there are areas of restricted shellfish harvesting around the airport (MDC, 1982).

According to the contractor for the Inner Harbor Planning Area, over 11 billion gallons of overflow enter the water every year. Seventy-five percent of these discharges are attributable to dry weather overflow and the rest can be accounted for by storm-related discharges. Dry weather overflows are the main cause of elevated coliform counts and floatable solids.

The contractor's report states that the water quality standards set for the Inner Harbor (they are less stringent than those set for the more recreational Dorchester Bay and Neponset River Estuary Planning Areas) can be met with the elimination of dry weather overflows (DWO) and the control of combined sewer overflows (CSO).

Table 3-4.

Combined Sewer Overflow Project Costs

(1979$)

Inner Harbor Planning Area

A. Inner Harbor

CSO Consolidated Pipelines	Capital costs [a/]	O&M Costs [b/]
Boston Waterfront	$5,858,000	N/A
South Boston	5,149,000	
East Boston-Southern Waterfront	6,221,000	
East Boston-Western Waterfront	8,156,000	
East Boston-Lexington Square	980,000	
Chelsea River Waterfront	4,097,000	
Reserved Channel	2,932,000	
CSO Treatment Facilities		
Fort Point Channel	45,542,000	816,000
Somerville	3,450,000	71,200
East Boston-Southern Waterfront	6,894,000	131,000
East Boston-Western Waterfront	6,400,000	48,000
East Boston-Lexington Square	3,575,000	31,700
Chelsea-Pearl Street	3,404,000	66,000
Chelsea Willoughby Street	2,005,000	39,100
Reserved Channel	2,032,000	50,400
Causeway Street	243,000	
Commercial Street	243,000	
Charles River Estuary		5,800
Management Practices		
Tidegate Improvements	250,000	118,000
Regulator Improvements	500,000	118,000
	107,921,000	1,495,300
B. Constitution Beach	315,000	8,700

a/ Based on June 1979 price levels (ENR 2900) and includes an allowance for engineering and contingencies.

b/ Based on 1979 price levels.

Source : O'Brien and Gere Engineers, 1980.

The main benefit of this plan is that it will clean up the Inner Harbor by reducing floating solids and thus reduce the consequent aesthetic problems, since the Inner Harbor is not now used for contact recreation, and there are no plans for it ever to be put to that use. Constitution Beach currently meets swimmable standards and the improvements at that site are to ensure that the standards will be maintained. It is difficult to predict if the improvements in water quality will result in more shellfish beds being opened for harvest.

3.5 Charles River Basin

The Charles River Basin includes the Back Bay Fens, the Muddy River, Alewife Brook and the Charles River itself. The basin is mixed fresh and salt water and is used mainly for non-contact recreation, both on the water and at the water's edge. The River is an extremely important and much used recreational source for local residents. Many sailing clubs maintain marinas on the River and every area college and many high schools use the River for rowing and sculling. The entire basin exceeds the water quality standards set for it by the state. Those standards (a rating of "C") allow non-contact recreational use. The main results of the basin pollution are extremely high coliform counts (both total and fecal), odors, floatables, debris and turbidity. The primary objectives of the MDC's efforts are to (Metcalf & Eddy, 1982):

a. reduce excessive levels of bacteriological organisms for public health reasons and remove floatables and turbidity for aesthetic reasons, and

b. remove solids and organic matter to prevent build up of benthic deposits.

In order to meet these objectives, the contractor designed a plan that involves the capture, transport and storage of most of the basin's combined sewer overflows. The plan's costs are presented in Table 3-5.

The Recommended Plan will reduce coliforms, floatable solids and suspended solids (and, therefore, turbidity) in the Charles River Planning Area. Secondary recreation (boating but not swimming) can be expected to increase because of the decrease in objectionable odors and floating debris.

3.6 Quincy Storm Sewers

Another source of pollutant loadings to Boston Harbor is the Quincy storm sewers. The Quincy storm sewers discharge waters with fecal coliform, BOD and TSS concentrations that are higher than levels expected from storm water runoff (Moore, 1980). Storm water contamination can result from cross-connections between sanitary and storm drains. These cross-connections can be due to broken pipes, exfiltration from sanitary sewers in disrepair and illegal "tie-ins" to the storm sewer system, although the latter has not been documented in Quincy. The problem in Quincy is compounded by the fact that North Quincy is relatively flat (especially adjacent to the beach areas) and, therefore, the drains in the area have slopes close to, and in some cases, less than the recommended minimums. This tends to cause blockages in the sanitary system and surcharges and exfiltration of sewage results, especially where pipes are cracked or have loose joints (Moore, 1977). A factor which increases the frequency of surcharging is the excessive infiltration and inflow into the

Table 3-5.

Combined Sewer Overflow Project Costs (1979$)

Charles River Basin

	Design Package	Capital Costs [a]	O&M Costs [b]
1.	Phase I In-System Modification	510,000	5,000
2.	Consolidation and Rebuilding of Boston Gatehouses #1 and #2	6,650,000	87,000
3.	Grit Removal and In-System Storage at Beacon Street and Charlesgate East with Phase II In-System Modification to MDC Fens Gatehouse	4,900,000	72,000
4.	Restoration of the Fens with Phase II In-System Modifications in the Muddy River Sub-area	2,000,000	20,000
5.	Connection from Stony Brook and Old Stony Brook Conduits to the Boston Main Drainage Relief Sewer	1,060,000	187,000
6.	Grit and Sludge Removal from Stony Brook and Old Stony Brook Conduits	4,750,000	
7.	Stony Brook Screening Disin-fection, and In-System Storage Facility near Tremont and Gurney Streets	7,500,000	360,000
8.	Stony Brook In-System Storage Facility and Base Brook Pumping Station at Green Street	10,400,000	116,000
9.	Phase II In-Line Storage Tannery Brook	5,900,000	14,000
10.	Surface Storage of Canterbury, Bussey and Stony Brooks	1,260,000	50,000

Table 3-5 (continued).

Combined Sewer Overflow Project Costs (1979$)

Charles River Basin

Design Package	Capital Costs [a]	O&M Costs [b]
11. St. Mary's Street In-System Storage	335,000	2,000
12. Concord, Rindge and Mass. Aves. Industrial Sewer Separation	3,600,000	
13. St. Mary's, Street Diversion to Cottage Farm Facility	2,800,000	4,000
14. Phase III In-System Modifications	360,000	11,000
15. Brighton-Allston Phase II In-Line Storage	10,850,000	88,000
16. Brighton-Allston Phase III Off-Line Storage	2,500,000	56,000
Management Practices and Monitoring Program	40,000	108,000
Total	65,415,000	1,180,000

[a] Based on June 1979 price levels (ENR 2900) and includes an allowance for engineering and contingencies.

[b] Based on 1979 price levels.

Source: Metcalf and Eddy, 1982.

sanitary system. Quincy is the last (i.e., downstream) city in the South Metropolitan Sewer District so that excessive flows from as many as 20 cities are channeled through Quincy on their way to the Nut Island Treatment Plant. It has been estimated that as much as 57% of the flow reaching Nut Island during a rainstorm is due to infiltration/inflow (Moore, 1981). Thus, the problem of correcting stormwater contamination in Quincy involves repair and rehabilitation of both the sanitary and storm sewer systems.

Several investigations and improvements have been undertaken in recent -years to locate sources of contamination of storm drains, in particular in order to reduce total and fecal coliform levels at Wollaston Beach to within acceptable levels, as determined by State standards (Moore, 1980). In addition, studies of the infiltration/inflow problem are continuing (Moore, 1981). It should be noted that other sources of contamination of the area's beaches include the Nut Island sewage treatment plant discharges and, in particular, recurring by-passes from both Nut Island and Moon Island.

Although estimates of treatment costs for the Quincy storm sewers comparable to those for the CSO planning areas are not available, recent studies give an indication of the order of magnitude of the costs involved (Table 3-6).

3.7 Summary of Options

The annual cost of implementing all five of the CSO and Storm Sewer plans is about $30 million (1982$). The costs of implementing portions of the plans or only some of the plans will, of course, be less.

Table 3-6. Potential Storm Sewer and Infiltration/Inflow Project Costs for City of Quincy (1981$)

Recommended Facility	Costs
Sewer System Evaluation Survey and Rehabilitation of Sewers	417,000
Construction of Relief Interceptors	
North Quincy	204,000
West Quincy	844,000
Quincy Point Diversion/ Relief Interceptor	132,000
Town River Bay Interceptor	703,000
Rehabilitation of Quincy Point Pump Station	40,000
Construction of Furnace Brook Emergency Relief Lift Station (MDC)	180,000
Total Capital Costs	2,520,000
Annual O & M Costs	-22,000

Note: Many problems remain and the city of Quincy has authorized a new engineering study so that these estimates of costs are preliminary only. They are taken from Table 8, Moore (1981), and do not include land and easement acquisition costs. The annual operation and maintenance costs are expected to decrease as a result of the infiltration/inflow removal program.

In order to gain swimming benefits at all beaches and shellfishing benefits at many of the currently closed shellfish beds in Boston Harbor, the Constitution part of the Inner Harbor plan, the entire Neponset River Estuary and Dorchester Bay Plans, and the Quincy plan must be implemented. Such a treatment option would cost more than $6.3 million a year (in 1982$), and it would affect neither the Charles River Basin nor the Inner Harbor proper.

Another option might be to implement only the Dorchester Bay and Neponset River Estuary plans. This would cost about $6 million (in 1982$) annually, but while making swimming safe in Dorchester Bay, it might compromise the water quality at Constitution Beach and Quincy Bay beaches in the long run as the population of these areas increases and wastewater discharges increase.

Table 3-7 shows the annual costs of the CSO and storm sewer options along with the approximate percentage reduction in pollutant loadings, including fecal coliform, floatable and suspended solids, and oil and grease. The top part of the table presents the four CSO plans as designated by the MDC. The bottom part shows the options used in the benefit-cost analyses in this study. The options as defined in the lower half of the table correspond more appropriately with the benefit estimates associated with the uses of the Harbor. For example, all the swimming and shellfishing uses affected by the CSOs (and therefore the corresponding benefits estimates) can be captured by including only the Constitution Beach portion of the Inner Harbor Plan plus the Dorchester Bay, Neponset River, and Quincy plans. The numbers in the table reflect incremental increases in annual costs.

Table 3-7. Incremental Costs and Potential Reductions

in Pollutant Loadings for the CSO Options

(Millions 1982$)

Treatment Alternative/ Receptor	Annualized Capital Cost a/	Annual O&M Cost	Total Annual Cost	Percentage Reduction in Pollutant Loadings b/
MDC PLANNING AREA DESIGNATION				
Inner Harbor				
a) Including Constitution	14.63	1.97	16.61	
b) Constitution only	0.04	0.01	0.05	50 - 99
Dorchester Bay	4.97	0.37	5.34	70 - 99
Neponset River	0.61	0.10	0.71	60 - 98
Charles River Basin	8.87	1.56	10.43	65 - 100
Implementation of all MIX designated CSO plans	35.44	4.00	33.39	50 - 100
STUDY AREA DESIGNATION				
Inner Harbor Constitution Beach only	0.04	0.01	0.05	50 - 99
Dorchester Bay/ Neponset River	5.59	0.47	6.06	60 - 99
Quincy Storm Sewers c/	0.27	-.02	0.25	60 - 99 d/
Above three plans combined	5.90	0.46	6.36	50 - 99
Charles River	8.87	1.56	10.43	65 - 100

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